US 20020071074A1

(19) United States

(12) Patent Application Publication (10) Pub. No.: US 2002/0071074 A1

NORITAKE et al. (43) Pub. Date: Jun. 13, 2002

(54) LIQUID CRYSTAL DISPLAY DEVICE

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(*) Notice: This is a publication of a continued prosecution application (CPA) filed under 37 CFR 1.53(d).

(21) Appl. No.: 09/447,769

(22) Filed: Nov. 23, 1999

(30) Foreign Application Priority Data

Nov. 26, 1998 (JP) ..... HEI. 10-335871

Publication Classification

(51) Int. Cl.[7] G02F 1/1335

(52) U.S. Cl. 349/112

(57) ABSTRACT

A reflection type LCD includes a TFT substrate **10** with TFTs and a counter electrode substrate **30** with a color filter **31**, a protection film **33**, a light-diffusing layer **34**, a counter electrode 33 and alignment film **36** which are provides on the side of the TFT substrate. Both substrates are bonded to each other in their periphery by an adhesive sealing material **24**. The light diffusing layer is provided only inside an area where the adhesive sealing material **24** is provided. In this configuration, the contact of an adhesive sealing is improved and material and intrusion of impurities such as moisture into a liquid crystal material is prevented.

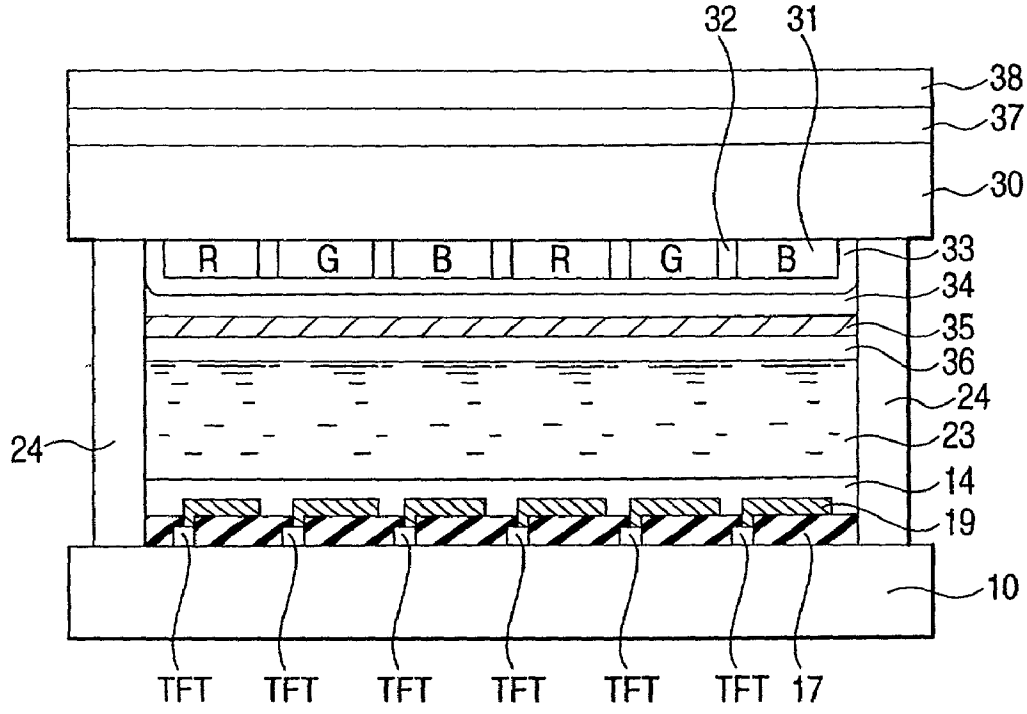
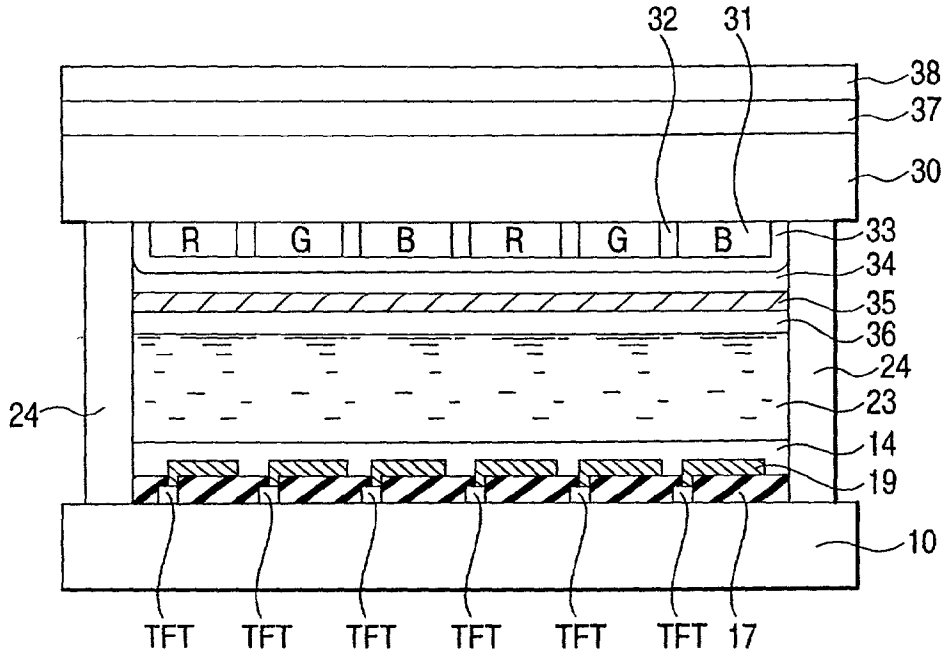


FIG. 1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31
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30
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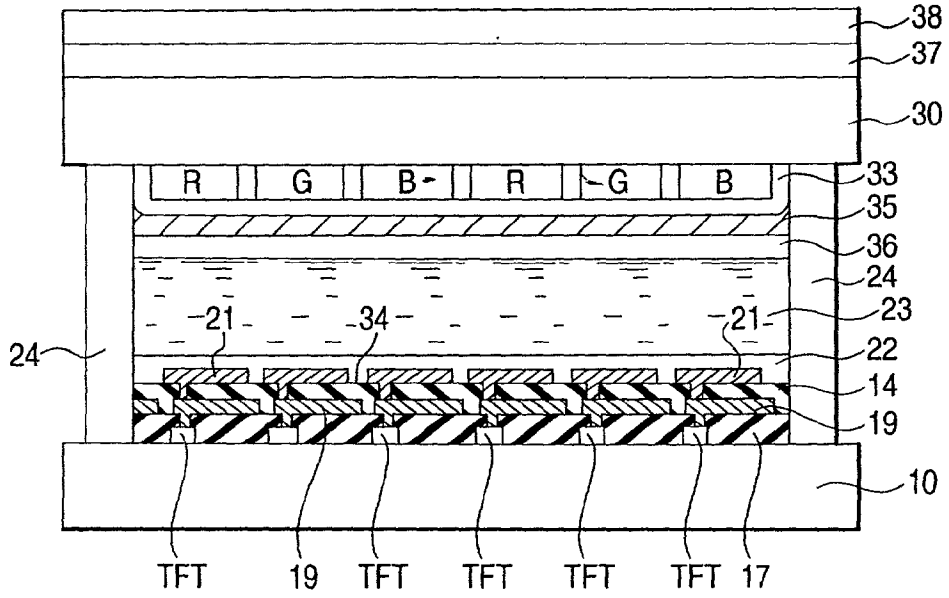
TFT
TFT
17

FIG. 2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37
30
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G
B
R
G
B
33
35
36
24
21
34
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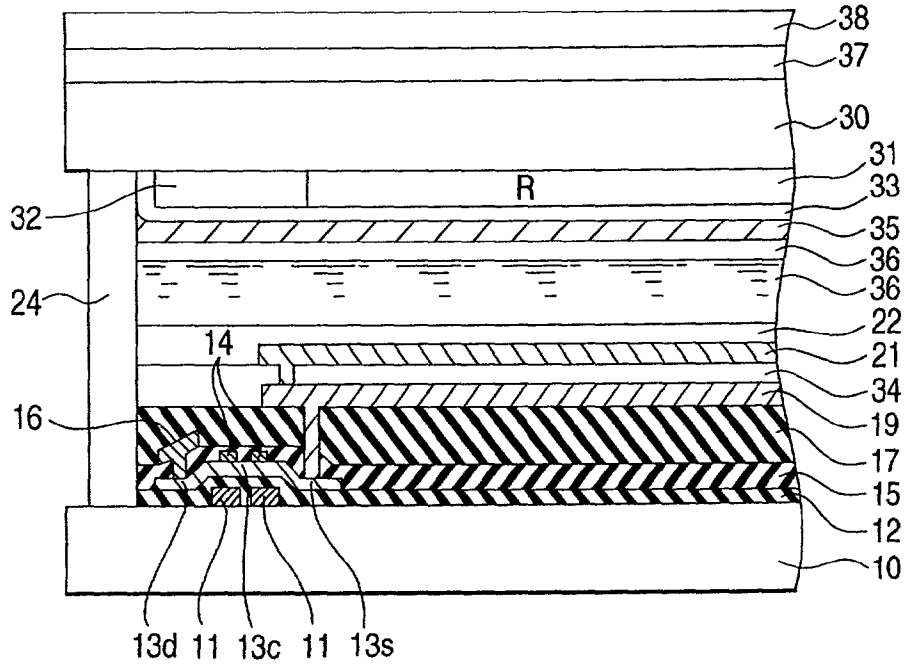
17

FIG. 3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37
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31
R
33
32
35
36
36
24
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15
12
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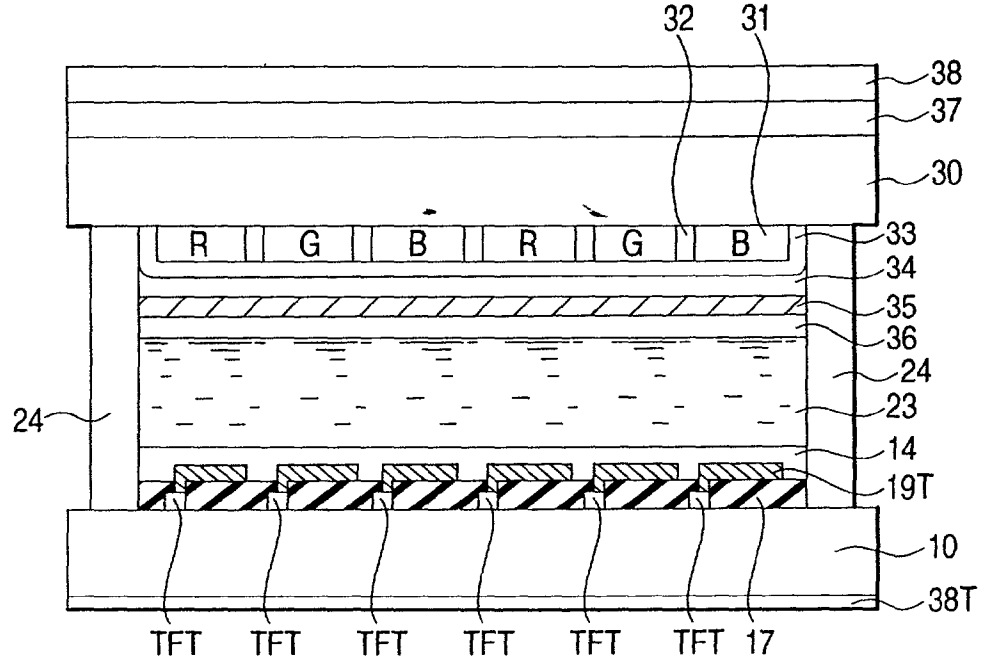
13d
11
13c
11
13s

FIG. 4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34
35
36
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19T
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38T
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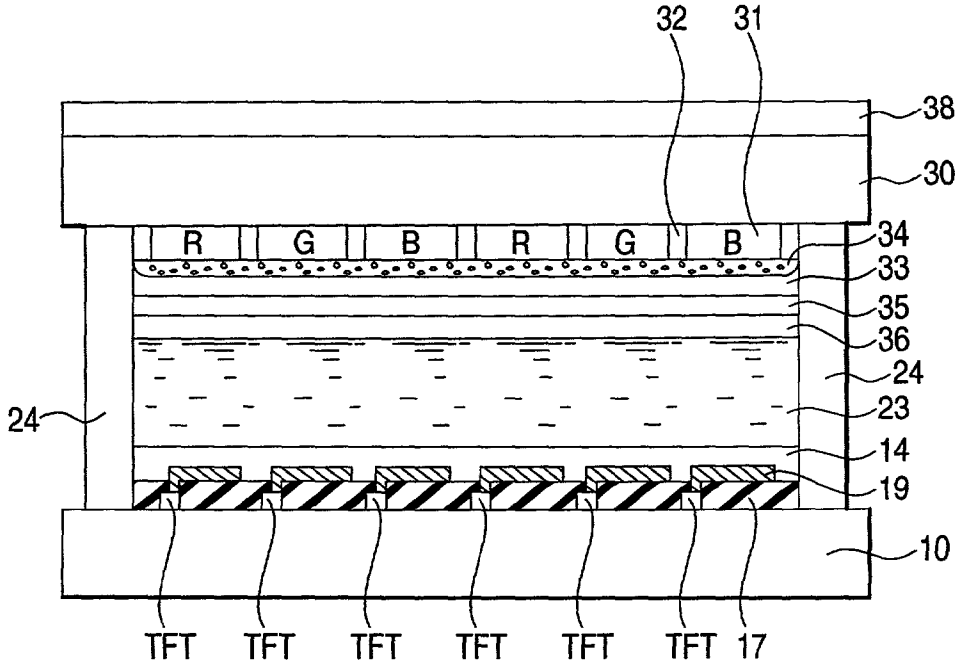
17

FIG. 5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31
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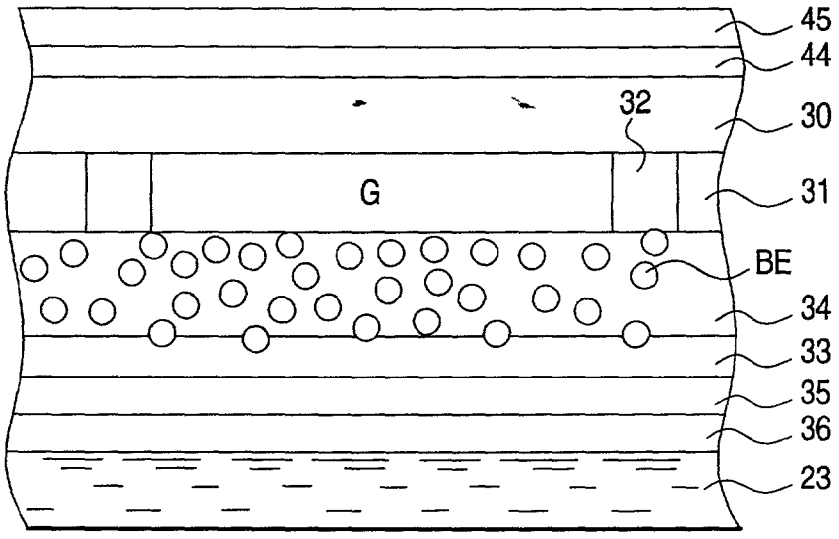
TFT
17

FIG. 6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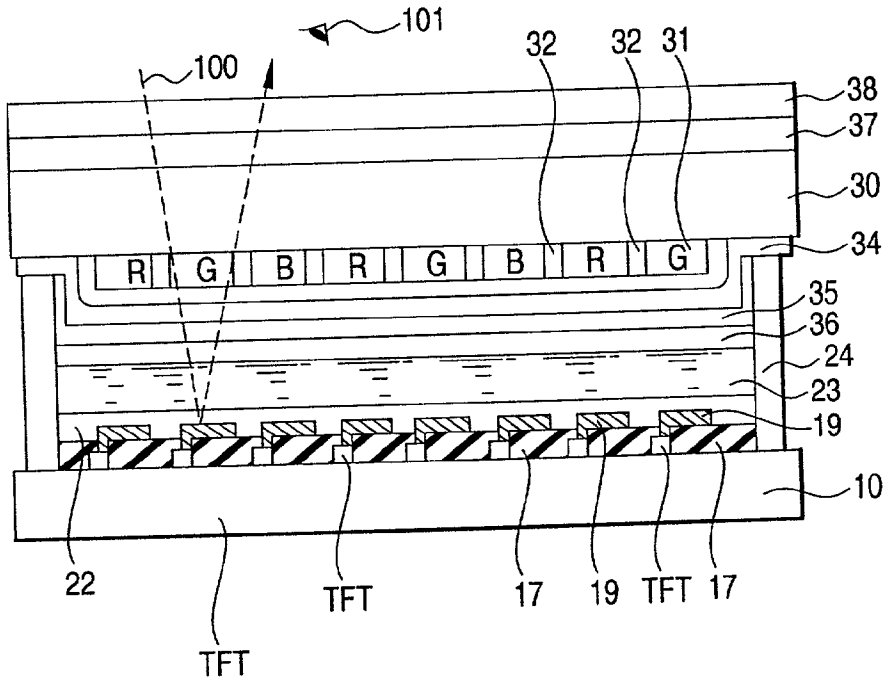
33
35
36
23

FIG. 7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36
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23
19
10
22
TFT
TFT
17
19
TFT
17

LIQUID CRYSTAL DISPLAY DEVICE

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a liquid crystal display device (LCD) provided with an optical diffused layer.

[0003] 2. Description of the Related Art

[0004] Conventionally, a reflection type display has been proposed which light incident from a viewer side is reflected to view a display.

[0005] **FIG. 7** is a sectional view of a conventional reflection type LCD.

[0006] As shown in **FIG. 7**, in the conventional reflection type LCD, on an insulating substrate **10** made of quartz glass, non-alkali glass, etc. general thin film transistors (TFTs) which are switching elements are formed.

[0007] A planarization insulating film **17** is formed on the resultant surface. Further, reflective display electrodes **19** of reflective material such as aluminum (Al) are provided, each of which is connected to the source of the TFT through a contact hole made in the planarization insulating film **17**. An alignment film **22** is formed on the entire surface inclusive of the respective reflective display electrodes. In this way, a side of the insulating substrate **10** provided with TFTs (hereinafter referred to as "TFT substrate") is completed.

[0008] A counter electrode substrate **30** of quartz glass, non-alkaline glass, etc. is facing to the TFT glass **10**. On the side of the TFT substrate of the electrode substrate **30**, a color filter **31** for the respective colors of red (R), green (G) and blue (B) provided with a black matrix **32** for light interruption is formed. A protection film **33** of resin is formed thereon. On the entire surface of the protection film **33**, a light-diffusing layer **34**, a counter electrode **35** and alignment film **36** are successively formed. On the side of a viewer **100**, on the counter electrode substrate **30**, a retardation plate **37** and a polarizing plate **38** are arranged. The counter electrode substrate **30** and TFT substrate **10** are bonded to each other in their periphery by an adhesive sealing material **24**so as to provide a gap therebetween. The gap is filled with twisted nematic (TN) liquid crystal **23**.

[0009] The light diffusing layer **34**, in which beads are mixed into a base material of transparent resin of e.g. polyimide, has a function of diffusing incident light.

[0010] As illustrated by solid line with an arrow, natural light **100** is externally incident from the polarizing plate **38** on the side of a viewer. The light reaches the light diffusing layer **34** through the retardation plate **37**, counter electrode substrate **30**, color filter **31** and protection film **33**. The light diffused from the light diffusing layer **34** is transmitted through the counter electrode **35**, alignment film **36**, TN liquid crystal **23** and alignment film **22** on the TFT substrate **10**, and is reflected by the reflective electrode **19**. The reflected light is transmitted through the respective layers in an opposite direction to the incident light, and is emitted from the polarizing plate **38** on the counter electrode substrate **30** to enter the eye **101** of a viewer.

[0011] However, in the conventional reflection type LCD, since the light-diffusing layer **34** extends to the bottom of the adhesive sealing material **24** bonding both substrates to each other, it is exposed to the outside air. Therefore, it will absorb moisture contained in the outside air so that the contactness at the interface between itself and the adhesive sealing material is deteriorated. The intrusion of moisture will deteriorate the liquid crystal material, thus leading to poor display.

SUMMARY OF THE INVENTION

[0012] An object of the present invention is to a reflection type LCD which can improve the contact of an adhesive sealing material and prevents intrusion of impurities such as moisture into a liquid crystal material.

[0013] In order to attain the above object, there is provided a liquid crystal display comprising:

[0014] a first substrate on the surface of which a first electrode is formed;

[0015] a second substrate with a second electrode facing to said first electrode;

[0016] a liquid crystal material which is sandwiched between said first and said second substrate; and

[0017] a sealing material for sealing said first and said second substrate on their periphery,

[0018] wherein a light diffusing layer is formed at least one between said first electrode and said first substrate and between said second electrode and said second substrate so that its edge is located inside said sealing material.

[0019] A second aspect of the device is a liquid crystal display according to the first aspect, wherein said light diffusing layer is made of an insulating material containing bead particles.

[0020] A third aspect of the device is a liquid crystal display according to the first aspect, wherein said first electrode is a display electrode which is connected to a switching element formed on the first substrate.

[0021] A fourth aspect of the device is a liquid crystal display according to the first aspect, wherein said light diffusing layer is made of a resin containing an acryl resin and bead particles.

[0022] A fifth aspect of the device is a liquid crystal display according to the first aspect, wherein said light diffusing layer is made of polyimide resin containing bead particles.

[0023] A sixth aspect of the device is a liquid crystal display according to the first aspect, wherein said first substrate is provided with a third electrode, a light diffusing layer formed so as to cover said third electrode and said first electrode which is formed on the light diffusing layer and is connected to the third electrode through a contact hole formed in said light diffusing layer.

[0024] A seventh aspect of the device is a liquid crystal display according to the sixth aspect, wherein said first electrode is made of ITO.

[0025] An eighth aspect of the device is a liquid crystal display according to the third aspect, wherein said switching element is a thin film transistor formed on the surface of said first substrate.

[0026] A ninth aspect of the device is a liquid crystal display according to the first aspect, wherein said light diffusing film is a resin film which is formed by spin-coating acryl resin containing bead particles each having a diameter of 1-5 μm.

[0027] A tenth aspect of the device is a liquid crystal display according to the first aspect, wherein said light diffusing layer has a thickness of 2-30 μm.

[0028] An eleventh aspect of the device is a liquid crystal display according to the first aspect, wherein a protection film is formed on said light diffusing layer.

[0029] A twelfth aspect of the device is a liquid crystal display according to the eleventh aspect, wherein said light diffusing layer has a refractive index equal to that of said protection film at least an interface therebetween.

[0030] A thirteenth aspect of the device is a liquid crystal display according to the eleventh aspect, wherein said insulating material of the light diffusing layer has a refractive index equal to that of said protection film.

[0031] A fourteenth aspect of the device is a liquid crystal display according to the first aspect, wherein said first electrode is a reflection type display electrode.

[0032] A fifteenth aspect of the device is a liquid crystal display according to the fourteenth aspect, wherein said second substrate on which a light diffusing layer is formed, is provided with a color filter layer as an underlying layer of said light diffusing layer.

[0033] A fifteenth aspect of the device is a liquid crystal display according to the fourteenth aspect, wherein alignment films are arranged between said first and said second electrode and said liquid crystal, respectively.

[0034] The above and other objects and features of the present invention will be more apparent from the following description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0035] **FIG. 1** is a sectional view of a first embodiment of the reflection type LCD according to the present invention;

[0036] **FIG. 2** is a sectional view of a second embodiment of the reflection type LCD according to the present invention;

[0037] **FIG. 3** is a sectional view of the vicinity of the sealing material of the LCD shown in **FIG. 2**;

[0038] **FIG. 4** is a sectional view of a third embodiment of the transmittance type LCD according to the present invention;

[0039] **FIG. 5** is a sectional view of a fourth embodiment of the reflection type LCD according to the present invention;

[0040] **FIG. 6** is a partially enlarged view of the LCD according to the fourth embodiment; and

[0041] **FIG. 7** is a sectional view of a conventional reflection type LCD.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Embodiment 1

[0042] **FIG. 1** is a sectional view of a first embodiment of the reflection type LCD according to the present invention. As shown in **FIG. 1**, in this embodiment, the structure on the TFT substrate **10**, which succeeds from provision of TFTs to that of the alignment film **22** on the reflective display electrodes **22** is the same as the conventional structure, is not explained here.

[0043] A counter electrode substrate **30** made of quartz glass, non-alkaline glass, etc. is arranged facing to the TFT glass **10**. On the side of the TFT substrate of the electrode substrate **30**, a color filter **31** for the respective colors of red (R), green (G) and blue (B) provided with a black matrix **32** for light interruption are formed. A protection film **33** of transparent resin is formed thereon to protect the color filter **31**. The entire surface of the protection film **33** is coated with a light diffusing layer **34** by a spinner. Thereafter, the light diffusing layer **34** is left in only an area inside the adhesive sealing material **24** which bonds the counter electrode substrate **30** and TFT substrate **10** to each other in their periphery.

[0044] On the light diffusing layer **34**, the counter electrode **35** and alignment film **36** are formed. On the side of the counter electrode substrate **30** not facing to the light diffusing layer **34**, the retardation plate **37** and a polarizing plate **38** are arranged.

[0045] The counter electrode substrate **30** and TFT substrate **10** are bonded to each other in their periphery by the sealing adhesive material **24** so as to provide a gap therebetween. The gap is filled with twisted nematic (TN) liquid crystal **23**.

[0046] The light diffusing layer **34** formed will be explained, hereafter.

[0047] The light diffusing layer **34** has a structure in which beads are mixed into a base material of transparent resin of e.g. polyimide, acryl, etc. The beads mixed into the base material have a function of diffusing incident light on the light diffusing layer **34**.

[0048] The light diffusing layer **34** is applied onto the protection film **33** by the spinner. After dried, a mask pattern, e.g. resist pattern which leaves the light diffusing layer **34** inside the sealing adhesive material **24** is formed on the light diffusing layer **34**. The light diffusing layer **34** at the periphery inclusive of the region where the adhesive sealing material **24** is formed is etched away. Namely, the light diffusing layer **34** is left only inside the adhesive sealing material **24**.

[0049] Thus, the light diffusing layer **34** is formed on the protection film **33** without being left under the adhesive sealing material **24**.

[0050] On the light-diffusing layer, the counter electrode **35** and alignment film **36** made of a transparent material such as ITO (Indium Tin Oxide) are formed.

[0051] As described above, the light-diffusing layer **34** is not formed under the adhesive sealing material **24** so that it is not brought into contact with the outside air. This prevents

the liquid crystal material **23** from being deteriorated owing to moisture contained in the outside air and improves the contact of the sealing adhesive material **24** with the light diffusing layer **34**.

[**0052**] In this embodiment, although the light diffusing layer **34** was formed on the protection film, it can be formed on the color filter **31** so as to provide the same effect.

Embodiment 2

[**0053**] **FIG. 2** is a sectional view of a second embodiment of the reflection type LCD according to the present invention. **FIG. 3** is a sectional view of the vicinity of the sealing material in **FIG. 2**.

[**0054**] This embodiment is different from the first embodiment in that the light diffusing layer **34** is formed on the side of the TFT substrate **10** but not on the side of the counter substrate **30**.

[**0055**] As shown in **FIG. 2**, on an insulating substrate **10** made of quartz glass, non-alkali glass, etc. general thin film transistors (TFTS) which are switching elements are formed. The insulating substrate **10** provided with TFTs is referred to as "TFT substrate"

[**0056**] As shown in **FIG. 3**, on the TFT substrate **10**, gate electrodes **11** made of refractory metal such as Cr, Mo, etc., a gate insulating film **12** and an active layer **13** of a polysilicon film are successively formed.

[**0057**] The active layer **13** includes a channel **13***c* formed above the gate electrodes **11**, and source **13***s* and drain **13***d* on both sides of the channel **13***c* which are formed by ion-implantation using a stopper insulating film **14** on the channel **13***c* as a mask.

[**0058**] An interlayer insulating film **15** composed of an SiO_2 film, SiN film and SiO_2 film deposited in this order is formed on the entire surface of the gate insulating film **12**, active layer **13** and stopper insulating film **14**,. A contact hole made so as to correspond to the drain **13***d* is filled with metal such as aluminum (Al) to form a drain electrode **16**. A planarization insulating film **17** made of e.g. organic resin is formed on the entire surface so that the surface is flat.

[**0059**] A conductive reflective material such as Al, Ag, etc. is deposited on the flattened insulating film **17** with the contact holes. Reflective display electrodes **19** are formed by photolithography.

[**0060**] A light diffusing layer **34** is applied on the entire surface of the reflective display electrodes **19** using a spinner.

[**0061**] The light diffusing layer **34** has a structure in which beads are mixed into a base material of transparent resin of e.g. polyimide, acryl, etc. The beads mixed into the base material have a function of diffusing incident light on the light diffusing layer **34**.

[**0062**] A contact hole is made in the light diffusing layer **34** to reach the reflective display electrode **19**. A transparent conductive material is deposited on the entire surface of the light diffusing layer **34** to form transparent electrodes **21** each having an area which is approximately equal to or slightly larger than that of the reflective display electrode **19**. An alignment film for alignment the liquid crystal **23** is formed on the entire surface.

[**0063**] Since the light diffusing layer **34** is provided on the reflective display electrode **19**, the interval between the liquid crystal **23** and the reflective display electrodes increases. Therefore, the voltage which should be applied to the liquid crystal display **23** may not be applied there. In order to obviate this inconvenience, a transparent electrode **21** is provided on the light diffusing layer **34**. Since each of the transparent electrodes **21** is connected to the reflective display electrode **34** through the contact hole formed in the light diffusing layer **34**. Therefore, the voltage applied to the reflective display electrode **19** is applied to the transparent electrode **21** and further applied to the liquid crystal **23**. Thus, the TFT substrate is completed.

[**0064**] On the counter electrode substrate **30** of quartz glass or non-alkali glass, on the side of the liquid crystal **23**, a counter electrode **35** facing to each transparent electrode is provided on the entire surface. An alignment film **36** of polyimide is formed on the entire surface.

[**0065**] On the side of the counter electrode substrate **30** where the liquid crystal is not arranged, i.e. on the side of a viewer, a retardation ($\lambda/4$) plate **37** and a polarizing plate **38** are provided in order.

[**0066**] Thus, the respective layers of the counter electrode substrate **30** are completed. The counter electrode substrate **30** and TFT substrate **10** are bonded to each other in their periphery by the sealing adhesive material **24** so as to provide a gap therebetween. The gap is filled with liquid crystal **23** to complete the reflection type liquid crystal display.

[**0067**] It should be noted that the light-diffusing layer **34** is not superposed on the adhesive sealing material **24**, but formed in a region inside the adhesive sealing material.

[**0068**] The light-diffusing layer applied on the reflective display electrode **19** is removed at the area where the peripheral adhesive sealing material **24** is arranged and the region outside of it.

[**0069**] Thus, the light diffusing layer inside the adhesive sealing material **24** will not be brought into contact with the outside air. This prevents the liquid crystal material **23** from being deteriorated owing to moisture contained in the outside air and improves the contact of the sealing adhesive material **24** with the light diffusing layer **34**.

[**0070**] In accordance with the present invention, the contact of the sealing adhesive material is improved, and the liquid crystal material is prevented from being deteriorated owing to moisture contained in the outside air.

Embodiment 3

[**0071**] **FIG. 4** is a sectional view of a third embodiment of the transmissive LCD according to the present invention. As shown in **FIG. 4**, the points that the LCD is different from the LCD of the first and second embodiments shown in FIGS. **1** to **3** are the following three points. First point of them is that a polarizing plate **38**T is formed on a rear surface of the TFT substrate **10**. Second point of them is that a transparent ITO electrode **19**T is formed in place of the display electrode **19**. Third point of them is that a retardation ($\lambda/4$) plate **37** formed on the rear side of the counter electrode substrate **30** as the first substrate is removed.

[0072] In **FIG. 4**, same numerals are added to the same parts of the first and second embodiments. And detailed explanation is submitted.

Embodiment 4

[0073] **FIG. 5** is a sectional view of a fourth embodiment of the reflective type LCD according to the present invention. **FIG. 6** is a partially enlarged view of the LCD according to the fourth embodiment.

[0074] In this embodiment, the light diffusing layer **34** is formed in such a manner that after the color filter **31** has been formed, its entire surface is coated with the acryl resin as a base material mixed with bead particles BE. In the coating step, the acryl resin is prepared as a liquid so as to have a viscosity of 20-30 c.p. and coated at rotation speed between 2000-3000 r.p.m. The thickness thereof ranges from about 8 μm to about 11 μm. The bead particles BE are roughly spherical in shape with a diameter of 2 -5 μm.

[0075] A transparent insulating film, e.g. acryl resin is applied onto the entire surface of the light diffusing layer **34** using a spinner to form the protection film **33**. A material of ITO is sputtered on the protection film **33** to form the counter electrode **35**. The alignment film **36** of resin such as polyimide for aligning the liquid crystal **21** is formed thereon. In this case, if the base material of the light diffusing layer **34** has a different refractive index from that of the protection film **33**, the light incident on the light diffusing layer **34** is reflected at the boundary between itself and the protection film **34** and outgoes toward the viewer side. In order to obviate such an inconvenience, the refractive index of the protection film **33** is preferably equal to that of the base material of the light diffusing layer **34**. In this embodiment, the protection film **34** is made of acryl resin having a refractive index of 1.4-1.6.

[0076] In this way, the respective layers are completed on the side of liquid crystal **21** of the counter electrode substrate **30** equipped with the light diffusing layer **34**. On the side where the liquid crystal is not arranged, i.e. the viewer side, of the counter electrode substrate **30**, a retardation (λ/4) plate **37** and a polarizing plate **38**T are successively formed.

[0077] As understood from the description hitherto made, even if the projections each with a height of about 200 A - about 2000 A are produced on the light diffusing layer **34** because of the bead particles BE (whose mixing quantity has been increased to improve the diffusion degree of the light diffusing layer **34** formed on the color filter film **31**), since the protection film **33** is provided on the light diffusing layer **34**, no projection occur in the alignment film **36**. Thus, the counter electrode and alignment film can have a flat surface.

[0078] Specifically, even if the light diffusing layer **34** has projections because of the bead particles BE, the protection film is formed on the light diffusing layer **34** so that it is made of the material capable of absorbing the height of the projections, i.e. providing a flat surface regardless with the unevenness of the surface of the light diffusing layer **34**, e.g. acryl resin. Therefore, the surface of the protection film becomes flat. Accordingly, the surfaces of the counter electrode **35** and the alignment film **36** which are formed on the protection film **33** can be also made flat.

[0079] As a result, the voltage applied to the counter electrode **35** is uniformly applied to the liquid crystal **21** so that no changes in the alignment of the liquid crystal is produced. This prevents poor display with inconsistencies. In addition, the provision of the light diffusing layer **34** can provide a uniform and bright display on the LCD. And when no voltage is applied to the electrodes, good alignment of the liquid crystal **21** is kept owing to the flatness of the surface of the alignment film.

[0080] Preferably the said protection film has a thickness of 0.1 to 10 μm, more preferably 1 to 5 μm.

[0081] Further the light diffusing film preferably is made of resin film which is formed by spin-coating acryl resin containing bead particles each having a diameter of 1 to 5 μm.

[0082] Preferably the light diffusing layer has a thickness of 2-30 μm, more preferably 20 to 30 μm.

What is claimed is:

1. A liquid crystal display comprising:

a first substrate on the surface of which a first electrode is formed;

a second substrate with a second electrode facing to said first electrode;

a liquid crystal material which is sandwiched between said first and said second substrate; and

a sealing material for sealing said first and said second substrate on their periphery,

wherein a light diffusing layer is formed at least one between said first electrode and said first substrate and between said second electrode and said second substrate so that its edge is located inside said sealing material.

2. A liquid crystal display according to claim 1, wherein said light diffusing layer is made of an insulating material containing bead particles.

3. A liquid crystal display according to claim 1, wherein said first electrode is a display electrode which is connected to a switching element formed on the first substrate.

4. A liquid crystal display according to claim 1, wherein said light diffusing layer is made of a resin containing an acryl resin and bead particles.

5. A liquid crystal display according to claim 1, wherein said light diffusing layer is made of polyimide resin containing bead particles.

6. A liquid crystal display according to claim 1, wherein said first substrate is provided with a third electrode, a light diffusing layer formed so as to cover said third electrode and said first electrode which is formed on the light diffusing layer and is connected to the third electrode through a contact hole formed in said light diffusing layer.

7. A liquid crystal display according to claim 6, wherein said first electrode is made of ITO.

8. A liquid crystal display according to claim 3, wherein said switching element is a thin film transistor formed on the surface of said first substrate.

9. A liquid crystal display according to claim 1, wherein said light diffusing film is a resin film which is formed by spin-coating acryl resin containing bead particles each having a diameter of 1-5 μm.

10. A liquid crystal display according to claim 1, wherein said light diffusing layer has a thickness of 2-30 μm.

11. A liquid crystal display according to claim 1, wherein a protection film is formed on said light diffusing layer.

12. A liquid crystal display according to claim 11, wherein said light diffusing layer has a refractive index equal to that of said protection film at least an interface therebetween.

13. A liquid crystal display according to claim 11, wherein said insulating material of the light diffusing layer has a refractive index equal to that of said protection film.

14. A liquid crystal display according to claim 1, wherein said first electrode is a reflection type display electrode.

15. A liquid crystal display according to claim 14, wherein said second substrate on which a light diffusing layer is formed, is provided with a color filter layer as an underlying layer of said light diffusing layer.

16. A liquid crystal display according to claim 14, wherein alignment films are arranged between said first and said second electrode and said liquid crystal, respectively.

* * * * *